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THE PRESENT STATUS OF THE HIGH CARBOHYDRATE-LOW CALORIE DIETS FOR THE TREATMENT OF DIABETES*

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FROM our clinical and laboratory experiences with the high carbohydrate-low calorie diet in hundreds of cases for more than one year, I believe that, subject to future discoveries in the metabolism of diabetes mellitus, this diet has come to stay. It has passed the experimental stage. The favourable results are reflected in the general condition of the patients, and are particularly well supported by the laboratory findings, and the reduction of insulin dosage. It is generally recognized that the clinical condition of diabetics may, at times, be very misleading. They may look and feel very well while actually being overfed with the aid of insulin. However, the persistent hyperglycæmia found in such cases is an indication that the diabetes is not under proper control and any mishap which tends to lower carbohydrate tolerance and interfere with the action of insulin, such as an injury or infection, may very rapidly lead to coma and death. The condition produced by such treatment corresponds somewhat to that which may readily be produced in depancreatized dogs.

When depancreatized dogs, treated with insulin, are made fat by feeding them with excess of carbohydrate, they exhibit much more acute symptoms of diabetes when insulin is withdrawn than are observed under the same circumstances in the case of thin dogs. The hyperglycæmia, ketonæmia and glycosuria are all more intense, but, most striking of all, the general symptoms are extremely acute, and a fat animal seldom lives for more than four days after discontinuing the insulin, whereas the thin one may live several weeks.[1]

The first and most important point which I wish to emphasize about this new diet is that our diabetics are not being over-fed. As a matter of fact, the caloric values of these diets are somewhat lower than with our previous low carbohydrate-high fat diets. (Note that these diets are called high carbohydrate-low *calorie* and not high carbohydrate-low *fat*.) Our respiratory metabolism data clearly indicate the absence of over-feeding. If due consideration is given to technical and other sources of error in the determination and in the interpretation of respiratory quotients, it may be stated, generally, that the respiratory quotient obtained in the fasting state is a fairly reliable index of the degree of storage of carbohydrates in the body; the greater the respiratory quotient, the greater the storage. Judging by the available data, our average respiratory quotient, obtained in the fasting state, in persons on this new diet is 0.76. Since the normal average is about 0.82, it may be assumed that our diabetics are utilizing all, or practically all, the food given each day; little or none is left for storage. The result is that our patients are kept about five or ten pounds below the generally accepted normal values.

Apropos of height-weight relationships, may I, parenthetically, outline here a very simple method of determining proper height-weight relationships. It is based upon calculations I made from a large number of available height-weight tables of different countries. According to our experiences with it during the last ten years, it has proved to be a very satisfactory guide. It is concerned with adults only and the proper weight of an individual is obtained as follows.—

Individuals are divided into four groups, according to their ages, namely, 15-25, 26-30, 31-35, and 35 years upward. Assuming all of them to be five feet tall, the corresponding weights of the different groups for this height are 120, 125, 130

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and 135 pounds respectively. Allow three pounds for each inch above five feet. In the case of females subtract five pounds from the final result. Thus:—

Male, aged 33 years, height 5 feet 6 inches:—
Normal body weight = 130 + (6 x 3) = 148 pounds.
Female, aged 38 years, height 5 feet 4 inches:—
Normal body weight = 135 + (4 x 3) = 147 pounds—
5 = 142 pounds.

For purposes of brevity, I shall not discuss the diet in detail, as this has been done on previous occasions ([2,3,4]). Consideration was then given to the effects of changes of treatment from low carbohydrate-high fat to high carbohydrate -low calorie diets upon blood and urine sugar, urinary nitrogen, plasma cholesterol, body weight, respiratory quotient, etc. There is very little to add to the average values then obtained.

Interpretation of the results of any form of treatment of diabetes mellitus depends, obviously, upon the type of diabetes concerned. For example, there is the juvenile diabetes; the acute diabetes of adults; that secondary to disease of the gall bladder and biliary passages; and diabetes associated with the various forms of cirrhosis of the pancreas; chronic progressive diabetes complicated by infection or some other condition which, *per se*, causes hyperglycæmia, (thyroid pituitary, etc.); and the uncomplicated chronic progressive diabetes.

From our experiences, so far at least, it appears that the diet is applicable to all of these forms. The cases I cite as representative of the different types of the disease have been selected because of the reliability of the patients in following the prescribed treatment and the regularity with which clinical and laboratory data were obtained. No form of treatment can be successful unless it is followed as prescribed. This applies more to this new diet than to any other previously made use of. Since the diet consists of large amounts of carbohydrate, small amounts of fat, and practically normal amounts of protein, and since patients find both the carbohydrates and protein portions adequate, the remaining temptation is, therefore, to take larger amounts of fat than prescribed. With larger amounts of fat, the patient is, obviously, receiving no diabetic treatment whatever. It is under these conditions that individuals who formerly have not required insulin must now make use of it, and those who have required it with the older forms of treatment must take more. May I here repeat the warning that if the physician is not reasonably certain in a given case that the patient will follow treatment as prescribed, he had better adhere to the older diets, moderate deviations from which are less likely to be harmful. It is our practice, as soon as we find that the patients have *deliberately* broken their diets, to return them to their older form of treatment. These older diets consist of 50, 75, 100, 125 and 150 grams of carbohydrate, depending upon the height-weight relationship of the individuals. The protein and fat contents of the diet in each case are practically the same, namely, 50 and 150 grams respectively.

It might be interesting to correlate all of our data obtained so far and deal with average values only. As stated, however, this will not be done, for there is very little to add to the observations made. Another reason is that conclusions based upon statistical data have not a universal appeal. I shall, therefore, briefly refer to results obtained in representative cases of the different types of diabetes.

JUVENILE DIABETES

CASE 1

(Hosp. No. 5997/30). This is the case of a boy six years of age who was first admitted to the Montreal General Hospital on October 17th, 1930. On admission, the urine contained large amounts of sugar and acetone bodies, and the blood sugar was 0.400 per cent. With the exception of the x-ray findings in the chest—moderate increase in the bronchial and peri-bronchial thickening—the findings at the physical examination were normal. On discharge from the hospital (Nov. 12th, 1930), the urine was free of sugar and acetone bodies and the blood sugar was normal, namely, 0.070 per cent. The body weight was 40¼ pounds, and the diet consisted of 182 grams of carbohydrate, 56 grams fat, and 63 grams protein. The insulin dosage was *twenty units* twice a day. Approximately one year later (October 6th, 1931), the urine was still free of sugar and acetone bodies, and the blood sugar was 0.164 per cent, three hours after his noon meal. He was taking *five units* of insulin twice a day. The body weight was 48 pounds.

Since his discharge from the hospital, he has returned to the clinic twenty times. On each occasion, with one exception, the urine was free of sugar and acetone bodies; the one exception was on May 19th, 1931, when the mother stated that she had some difficulty the day before with the syringe—"It leaked badly".

ACUTE DIABETES OF ADULTS

CASE 2

(Hosp. No. 6000/29). This patient was admitted on October 14th, 1929, with a history of a sudden onset of polyuria, weakness, and rapid loss of weight approximately three weeks prior to admission. The findings of the physical examination were negative, with the exception of x-ray findings in the chest—in the left infraclavicular region there was a suggestion of tuberculous infiltration. On admission, the urine contained large amounts of sugar, but no acetone bodies, and the blood sugar was 0.714 per cent. On discharge from the hospital (October 30th, 1929), the urine was free of sugar and acetone bodies, and the blood sugar was normal, namely, 0.091 per cent. The body weight was 140 pounds. The insulin dosage was *ten units* once a day. The diet then consisted of 125 grams of carbohydrate, 150 grams fat, and 50 grams protein. At the six different visits to the clinic until September 2nd, 1930, the urine was always free of sugar and acetone bodies, and the blood sugar was normal. On September 2nd, his diet was changed to 254 grams of carbohydrate, 45 grams fat, and 75 grams protein.

With two exceptions since then, on seven different occasions, the urine has been free of sugar and acetone bodies, and the blood sugar was normal. On the two exceptional days, the blood sugar was 0.178 and 0.137 per cent, respectively. The body weight is still 140 pounds. He is now receiving no insulin. In other words, in this case the diet was changed from 125 grams of carbohydrate to 254 grams without additional insulin, and without impairment in the carbohydrate metabolism. The plasma cholesterol data show a remarkable change. At the three last visits before the diet was changed in 1930 (June 28th, August 1st and September 2nd), they were 0.326, 0.387 and 0.315, respectively. Since then they have not only been normal but below normal, and, at the last visit (September 18th, 1931), that is, about one year since the diet was changed, the plasma cholesterol was 0.134 per cent.

"GALL BLADDER" DIABETES

CASE 3

(Hosp. No. 2639/30). A physician, aged 43 years, a diabetic of four years' duration, returned for a periodic examination in May, 1930. The only associated condition was chronic cholecystitis. The gall bladder was found to be definitely diseased. Two attempts to visualize it with the aid of phenoltetraiodophthalein administered intravenously failed. On discharge from the hospital, the urine was free of sugar and acetone bodies, and the blood sugar was on the border-line of the normal, namely, 0.122 per cent. The diet since November, 1929, consisted of 150 grams of carbohydrate, 140 grams fat, and 50 grams protein, and the insulin dosage was *ten units*, one-half hour before the morning and one-half hour before the evening meals. The diet was then changed to 272 grams of carbohydrate, 45 grams fat, and 78 grams protein, and on October 1st, 1931, sixteen months later, he writes "I am always sugar free and feel well, with blood sugar within the normal limits. I have gained no weight, in fact am a little lighter. Playing much golf. My insulin dosage is five units three times a day".

Here, therefore, we have a case of diabetes complicated by chronic cholecystitis in which the carbohydrate content of the diet was changed from 150 grams to 272 grams, not only with no additional insulin but with a slight reduction. It is very difficult to attribute this change to improvement of the cholecystitis, since nothing was done for it. Incidentally, the low fat content of this diet fits in with the generally accepted treatment for biliary disease. Also, if our present conception of liver function is correct, conditions which tend to lead to progressive hepatitis demand liberal carbohydrate diets in order to prevent the latter.

If we calculate the caloric content of this diet, it is obvious that this physician is receiving a much smaller amount of food than is theoretically required according to calculations based upon body weight and height. It would appear from such experiences that the Law of Conservation of Energy does not apply to the human body. This, however, would be a ridiculous assumption. Energy does not arise from nothing; wherever it is active it must have been potential elsewhere. We, therefore, have to seek another explanation. There are abundant metabolic data to support the view that if a person is exposed for any length of time to a diet below the ordinary requirements, the metabolism is lowered—the energy expenditure becomes less. It would otherwise be difficult to explain the fact that hundreds of our diabetics have been living upon less than 2,000 calories a day for a number of years, and with such diets have been attending to their usual duties.

A striking example of the possible difference between actual and theoretical calorie requirements is found in

CASE 4

C.S. (Hosp. No. 2353/31), a young diabetic, 23 years of age, a very active athlete and now engaged in hockey. Though I do not presume to give an opinion on sports, I have the impression that there is perhaps no other game which demands greater muscular exertion than Canadian hockey. This hockey player is receiving 254 grams of carbohydrate, 45 grams fat, and 72 grams protein, and maintains his body weight between ten and twelve pounds below the normal for his height and age.

CHRONIC PROGRESSIVE DIABETES COMPLICATED BY INFECTION AND INJURY (OPERATION).

A most striking example of the possible course of events in this type of diabetes was met with recently.

CASE 5

A male (Hosp. No. 4461/31), 64 years of age, a diabetic of three years' duration, was admitted in a state of precoma. Drowsiness was marked; the breathing was of the deep, laboured type; the tongue was dry and beefy in appearance, and presented a sandpaper-like sensation on palpation; the eyeballs were soft, and there was a marked odour of acetone on the breath. In addition, the urine contained large amounts of sugar and acetone bodies, and many casts, and the blood sugar was 0.588 per cent. Fifty units of insulin were administered subcutaneously, followed by twenty units every four hours. The following morning, the clinical signs of the acidosis were absent. The urine still contained sugar and acetone bodies, but this could readily be explained by the "residual" urine in the bladder. The blood sugar was normal, namely, 0.122 per cent. The associated conditions were cardio-vascular-renal disease, with marked optic neuritis. There was also prostatic hypertrophy and cystitis. He gave a history of marked thirst, polyuria, and loss of weight, for three months prior to admission, approximately 40 pounds.

Following our usual treatment of coma, the food for the first forty-eight hours was restricted to water, clear, fat-free and well salted broth, tea, coffee and orange juice; the equivalent of 10 grams of sugar was given with each dose of insulin. On August 9th, he received 20 units of insulin every six hours and on August 10th, 10 units every eight hours. On August 11th, dietetic treatment was instituted. He was given the high carbohydrate—low calorie diet on the "ladder" basis, and 20 units of insulin twice a day, one-half hour before the morning and evening meals. From the beginning of the dietetic treatment until the day of discharge the urine was always free of sugar and acetone bodies, and the blood sugar was normal or nearly normal in the fasting state, except during the first few days of treatment. On September 1st, twenty days after admission, a supra-pubic cystotomy was performed under local anæsthesia and on September 11th, ten days later, the prostate was enucleated under ether anæsthesia. On September 27th, it was possible to discontinue insulin treatment. On October 7th, he was discharged from the hospital. His records in the Out-door Clinic for Diabetes since his discharge show that his urine is still free of sugar and acetone bodies on a diet of 218 grams of carbohydrate, 45 grams fat, and 69 grams protein.

To summarize, we have a male, 64 years of age, with a history of diabetes of three years' duration, his condition complicated by cardio-vascular-renal disease, prostatic enlargement, cystitis, and pyuria, admitted to the hospital in a state of pre-coma. Following the usual treatment for coma, he was given a high carbohydrate-low calorie diet, and in spite of the advanced stage of the diabetes on admission underwent a supra-pubic cystotomy and later an enucleation of the prostate. Shortly after, it was possible to entirely discontinue the use of insulin, though the carbohydrate content of the diet was over 200 grams. Incidentally, such diets conform to the generally accepted practice of giving liberal carbohydrate diets prior to surgical procedures.

There is an obvious difficulty in the interpretation of the above data. It is generally recognized that in the types of diabetes mentioned, carbohydrate tolerance tends to improve rapidly following treatment. For example, with the exception of pneumonia after the crisis, there is probably no more striking change in the metabolism of an individual than in a diabetic suffering from an infection after removal of the latter. In juvenile diabetes rapid improvement in carbohydrate tolerance is also frequently noted. It may, therefore, be possible that herein is the explanation of the above results. Our former experiences with older diets, however, do not tend to support this view. This explanation also hardly applies to the so-called chronic progressive diabetes without complications. Though occasionally one may meet with improvement in carbohydrate tolerance, particularly in elderly people with diabetes of some years' duration, our records support the view that once such diabetics require insulin, they always require it. Undoubtedly, there are a large number of persons who shortly after discharge from the hospital are able to do with little or none at all. The improved carbohydrate tolerance is apparently due to exercise. However, such improvement as has been noted with the new diet has not been met with before, except rarely.

Uncomplicated Chronic Progressive Diabetes

The following two cases are representative samples of the possible course of events in chronic progressive diabetes without complications. In one the diabetes was controlled without insulin, and in the other insulin was required.

Case 6

(Hosp. No. 6236/30), a male, aged 27 years. On the day of discharge after his first admission in October, 1929, the diet consisted of 125 grams of carbohydrate, 140 grams fat and 50 grams protein. The urine was free of sugar and acetone bodies, and the blood sugar was normal. He was a very severe diabetic and required eighty units of insulin a day.

On October 28th, 1930, he was re-admitted, in order to substitute the new high carbohydrate-low calorie diet for the old one. It was then found that he could tolerate a diet of 254 grams of carbohydrate, 45 grams fat, and 75 grams protein with 40 units of insulin a day, 25 units before the morning and 15 units before the evening meal. On discharge from the hospital, on November 10th, it was found that the urine was free of sugar and acetone bodies, and the blood sugar was normal, namely, 0.108 per cent. He was a very active man and his body weight had decreased from 148½ pounds in October, 1929, to 134 pounds in April, 1931. In view of the loss of body weight, the diet was further increased to 290 grams, and two months later to 308 grams of carbohydrate.

He returned for observation in October, 1931, and on discharge from the hospital it was found that on 35 units of insulin he could tolerate a diet of 308 grams of carbohydrate, 45 grams fat, and 84 grams protein. The urine was free from sugar and acetone bodies, and the blood sugar was normal.

Here, therefore, we have a man who has been on the high carbohydrate-low calorie diet since October, 1930, whose diet has been changed from 125 grams carbohydrate to 308 grams and the insulin dosage from eighty units to thirty-five units.

Case 7

A.A.B., a male, aged 56 years, a diabetic of three years' duration, who had been under constant observation in the clinic since his diabetes was first discovered in 1928. Though he had always been sugar-free on a diet of 125 grams of carbohydrate, 140 grams fat, and 60 grams protein, the blood sugar has never been normal, ranging between 0.130 and 0.200 per cent. The cholesterol content of the plasma was also high, ranging between 0.333 and 0.416 per cent. On April 16th, 1931, in spite of hyperglycæmia (the blood sugar was 0.200 per cent) the diet was changed to 254 grams of carbohydrate, 45 grams fat, and 75 grams protein. On June 11th, 1931, the carbohydrate content of the diet was further increased to 272 grams. Since then, the urine has always been sugar free and the blood sugar normal or nearly normal. The last records show a blood sugar of 0.116 per cent and a cholesterol of 0.216 per cent.

Indications for the Use of Insulin

Interpretation of the above data depends, obviously, upon the method used in this study for determining whether individuals did, or did not, require insulin. As is well known, there are a variety of procedures. From my own experience, I must say that, unless the plan described here is adhered to, it is quite difficult to determine in cases in which insulin dosage has been reduced whether the initial amounts were actually necessary. Clinical impressions may be very misleading, and have often explained apparent improvement of carbohydrate tolerance following institution of insulin treatment. Careful metabolic studies, however, have frequently revealed in such cases the fact that no insulin was required

at the beginning of treatment; diet alone would have sufficed. From a careful statistical analysis, with proper statistical methods, of many hundreds of cases, the writer drew the conclusion that insulin does not improve carbohydrate tolerance, except in certain types of diabetes; its removal is followed by a corresponding loss of capacity to utilize sugars.[5] Our routine in *each* case is as follows:—

ROUTINE TREATMENT

On admission to the hospital, the patient is given a starvation diet (green days) for two or three days. The diet is then gradually increased on a "ladder" basis. Urinary sugar is estimated quantitatively daily, and the blood sugar every second day in the fasting state. Except in very severe diabetes, with such treatment the glycosuria disappears, and the blood sugar not infrequently returns to the normal level within the first few days of observation. With further increase of diet, however, hyperglycæmia may or may not reappear. If the hyperglycæmia is marked, whether or not accompanied by glycosuria, insulin treatment is immediately instituted. If the hyperglycæmia is moderate, the blood sugar ranging between 0.13 and 0.200 per cent, the individual is asked to assist the nurses in their ward duties so that the exercise will conform as much as possible to his ordinary activities. If, following such activity, the blood sugar decreases in spite of a further increase of diet, no insulin is given. If, however, in spite of activity, hyperglycæmia persists, insulin treatment is then instituted, whether the urine does or does not contain sugar.

We begin with about ten units of insulin once a day, one-half hour before the morning meal. If with this dosage the blood sugar remains normal, or shows slight hyperglycæmia only with increase of diet, the insulin is not increased. If an increase is required, the addition is made before the evening meal. Further additions are made by adding five units first to the morning and then to the evening meal. If two doses a day do not suffice, we partition the urine in order to determine when glycosuria occurs most frequently. Thus:—

Specimen	*Represents*
8 a.m. to 12 noon	Breakfast
12 noon to 5 p.m.	Lunch
5 p.m. to 10 p.m.	Evening meal
10 p.m. to 7 a.m.	Night metabolism
7 a.m. to 8 a.m.	Fasting state

With this plan it may be found that the individual requires not more insulin but a different distribution of dosage. When, therefore, by the procedure outlined in these studies, we found the insulin dosage was reduced in a given case, I believe it is a reasonable assumption that the reduction was due largely to the diet and not to other possible contributing factors.

That these diets have resulted in a fundamental alteration of metabolism of the diabetic is suggested from urinary nitrogen, plasma cholesterol and other metabolic data. Some of these were shown in a previous report.[3] The altered nitrogen metabolism is probably the chief explanation of the general well-being of these patients. Whereas, as is well known, with diets of high fat content it was almost impossible to attain and maintain nitrogen equilibrium, the new diets almost invariably cause nitrogen retention in the early stages of treatment. An explanation of this phenomenon may be found in Kayser's experiments and those of Talquist, quoted by Sherman[7], on the sparing action of fat compared with that of carbohydrate. These experiments clearly demonstrate that, on diets of equal caloric value, when fat was substituted for carbohydrate there was a marked increase of protein katabolism with corresponding loss of nitrogen from the body. With continuation of fat, there was progressive loss of nitrogen; whereas, on returning to carbohydrates, not only was the loss of protein stopped but the body began almost at once to replace the protein it had lost.

EFFECT OF DIET IN CARDIO-VASCULAR DISEASE

That these diets may have an especially favourable influence on patients with cardio-vascular disease is suggested from the following cases.

CASE 8

A.A.A. (Hosp. No. 3953/29), male, aged 59 years, was admitted to the Montreal General Hospital on June 7th, 1929, with a history of diabetes of 14 years' duration and complaints of "burning sensation and shortness of breath on walking and, at times, pain". The diagnosis was chronic myocarditis with angina pectoris. There were the usual features of cardio-vascular disease (mild hypertension, slight cardiac hypertrophy, accentuation of the aortic second sound, and thickened radial vessels. The fundi also showed thickened vessels). The electro-cardiograph showed inversion of the T-wave in both leads 1 and 2, and variations from the normal usually regarded as evidence of impaired muscle tone. The findings were, otherwise, essentially negative, except for the diabetes. There was no history, nor were there any physical, x-ray, or other laboratory signs, of biliary disease. The lungs were found normal, both by physical and x-ray examination. The x-ray showed no calcification of the arteries of the feet. The Wassermann test was negative. Briefly, the metabolic data were as follows.

When the patient was first seen there was a marked hyperglycæmia (blood sugar = 0.285 per cent) and glyco-

suria, but no acetonuria. He was given the usual treatment. After three "green days", the diet was gradually increased to the maintenance level. On discharge, the urine was free of sugar and acetone bodies and the blood sugar was normal (0.111 per cent). The diet consisted approximately of 50 grams of carbohydrate, 150 grams fat, and 50 grams protein. No insulin was required to maintain this ideal state. Since discharge from the hospital he returned at regular intervals for examination. The urine was always sugar-free, but the blood sugar ranged between 0.15 and 0.17 per cent. The cholesterol was always high, ranging between 0.400 and 0.577 per cent. In spite of the fact that he was following his diet, and adhered to the usual rules as to the régime for his heart disease (avoidance of excitement, tobacco, etc.), there was no improvement in the condition of the heart; the anginal attacks became more frequent and more severe. On October 20th, 1930, he had reached the state in which he could hardly walk more than a few minutes without precipitating an attack. His blood showed a greater degree of hyperglycæmia; the blood sugar was 0.200 per cent. In spite of this hyperglycæmia, his diet was changed to 272 grams of carbohydrate, 56 grams fat and 78 grams protein. He was warned to watch his urine carefully and report any glycosuria. Nitroglycerine was then also prescribed. He returned for examination on April 24th, 1931, that is, about seven months later, and the history was as follows.

His weight was approximately the same; in October he weighed 163 pounds and he now weighed 164 pounds. He stated that he felt better and the heart attacks were much less frequent and less severe; he could walk a much greater distance and, as a matter of fact, felt, as he put it, "tip top". He was also taking less nitroglycerine. There was no glycosuria during the interval. The blood sugar, in the fasting state, on this day was 0.188 per cent. But the most striking change of all was found in the electro-cardiographic tracing; with the exception of left ventricular preponderance and a slight degree of notching of the R-deflection in all leads, the electro-cardiogram was normal in all respects; the T's were upright and of a maximum magnitude, indicating 0.0002 volts, which is practically normal at the age; the P-R interval was 0.11 seconds; the Q-R-S occupied 0.09 seconds. As a matter of fact, the notching of the R-deflection was so small that our cardiologist, Dr. C. C. Birchard, regarded it as of no prognostic importance. The finding of left ventricular preponderance was, also, regarded as of little or no importance at the patient's age.

The interpretation which I would suggest of the above findings is that improvement was the result of supplying the heart muscle with the important food required for its proper function, namely, glycogen. Here, incidentally, we have a patient whose diet was changed from 50 grams of carbohydrate to 272 grams without the use of insulin with no resultant glycosuria nor increase of blood sugar, *in spite of the hyperglycæmia immediately prior to the change.*

CASE 9

In the other, and somewhat similar case (Hosp. No. 5527/24), the changes in the heart muscle prior to the increase of carbohydrates in the diet were not as marked. However, following change of diet, the electro-cardiogram showed increase of the amplitudes of the Q-R-S deflections, and the T-deflections, from being almost zero in magnitude, increased to a normal size and contour.

EFFECTS OF TAKING LARGER QUANTITIES OF FAT THAN ALLOWED

The following case, because of the complete data and the reliability of the patient, is an example of the possible effects of ingestion of larger amounts of fat than allowed in the diet.

CASE 10

(Hosp. No. 401/31), a girl, 23 years of age, was admitted to the Montreal General Hospital on January 21st, 1931, with a history of thirst and polyuria and a rapid loss of body weight for one month prior to admission. The results of the physical examination were essentially negative, other than the diabetes. On admission, the urine contained large amounts of sugar, some acetone bodies, and the blood sugar was 0.250 per cent in the fasting state. The high carbohydrate-low calorie diet was given on the "ladder" basis and on discharge from the hospital, February 2nd, the urine was free of sugar and acetone bodies, and the blood sugar was on the border-line of normal, namely, 0.122 per cent. The diet consisted of 236 grams of carbohydrate, 56 grams fat, and 72 grams protein. No insulin was required.

On the three subsequent visits to the diabetic clinic (February 28th, March 28th, and May 2nd), the blood sugar was 0.277, 0.208 and 0.333 per cent, respectively. In spite of careful examination, there was no reason to believe that this patient was not following the diet as prescribed; while in the hospital she was classified as "very reliable". On May 2nd, however, when it was explained that her blood sugar was not only not normal but high and increasing, and that we could find nothing to account for this, as there was no history of cold or other infection, etc., of her own accord she outlined her usual diet for the day. It was then discovered that she was inadvertently taking more fat than allowed; she was taking bacon for breakfast, assuming that, because it was lean, the fat content would not be greater than other lean meats.

Because of both the general condition and the laboratory data, it was considered that insulin was now necessary. As she was quite intelligent, she was not readmitted to the hospital but allowed to carry out instructions at home. She was to take ten units of insulin twice a day, one-half hour before the morning and one-half hour before the evening meal, and to commence treatment again by starvation and gradually increase the diet, following the same practice as when she was in the hospital, until it reached 236 grams of carbohydrates. This she did and the following were the results:—

Date	*Blood sugar (per cent)*
May 12th	0.147
May 18th	0.161
May 30th	0.200
June 13th	0.147
July 2nd	0.158

On July 2nd, because of the history of frequent, though mild, insulin reactions, the diet was increased to 254 grams of carbohydrate and the insulin dosage was reduced to ten units once a day. Since then, the urine has remained free of sugar and acetone bodies, and the blood sugar has been normal or nearly normal.

The plasma cholesterol data are rather striking. On discharge from the hospital the figure was 0.214 per cent. When the blood sugar had reached 0.333 per cent, because of the bacon, the cholesterol was 0.342 per cent. With return to her diet without the bacon, the cholesterol immediately dropped to 0.214 per cent, and the last reading was 0.185 per cent.

To summarize, we have here a young girl with an acute diabetes and rapid downward progress prior to admission to the hospital, who was able to tolerate a diet of 236 grams of carbohydrate without the use of insulin; who shortly after discharge from the hospital inadvertently increased the fat content of her diet, which act was followed by the loss of carbohydrate tolerance to the point

where insulin was required. With return to her proper diet, she was not only able to reduce the insulin disage by ten units but to increase the carbohydrate content of the diet to 254 grams.

TEMPORARY GLYCOSURIA WITH THE HIGH CARBOHYDRATE-LOW CALORIE DIET

Occasionally we meet with glycosuria in the absence of dietary indiscretion, but characterized by its temporary nature. The blood sugar in such cases is always normal or nearly normal in the fasting state, and without alteration of either diet or insulin the condition disappears and may shortly after reappear. From our studies so far we have no reason to believe that this temporary glycosuria is accompanied by loss of carbohydrate tolerance. Because of the importance of the recognition of the phenomenon and the necessity of further studies, a case is cited here as an example:—

CASE 11

(Hosp. No. 5147/31). A boy, 16 years of age, a diabetic of two years' duration, was admitted to the Montreal General Hospital on September 23rd. He had been attending the clinic for diabetes at this hospital since January, 1929. His diet since May, 1930, had consisted of 218 grams of carbohydrate, 56 grams fat, and 69 grams protein, and he was taking ten units of insulin twice a day. He was an ideal patient. The urine was always free of sugar and acetone bodies, and the blood sugar normal or nearly normal until November of the same year, when his mother died. With the radical change in home conditions, it was impossible for him to have proper treatment for some time. Though glycosuria appeared occasionally only, hyperglycæmia was found for some time, practically at every visit to the clinic.

On September 12th, 1931, at his last visit to the outdoor clinic, he complained of a "painful lump" on the left cheek. He obviously had some deep inflammatory lesion; the skin over the affected area was normal in appearance. He was referred to the Surgical Clinic, from which, in turn, he was admitted to the hospital. While in the hospital, a diagnosis of actinomycosis was made. There was some febrile disturbance, and accompanying this, on admission, the urine contained sugar and acetone bodies, and the blood showed a marked grade of hyperglycæmia, namely, 0.357 per cent. Because of the infection, he was not placed on a starvation diet but was given his usual food, namely, 218 grams of carbohydrate, 45 grams fat and 69 grams protein, and, according to our practice in infections, was given insulin every six hours rather than in relationship to meals. By giving him ten units of insulin at each dosage, the following morning the urine was free of sugar and acetone bodies, and the blood sugar was normal.

On October 14th, in view of the absence of glycosuria and marked hypoglycæmia, the diet was further increased to 254 grams of carbohydrate, and the insulin dosage from ten units every six hours, that is, 40 units a day, to 15 units every eight hours, that is, 45 units a day. The blood sugar remained perfectly normal and, on October 21st, because of the marked hypoglycæmia* the insulin was reduced to ten units every eight hours, at which level it has been kept, because of the persistent, though slight, discharge from the operative wound and occasional febrile reaction. For no apparent reason, a twenty-four sample of urine occasionally contains sugar and, *without change of diet or insulin dosage*, conditions adjust themselves the following day. Considering the diet, the amounts of sugar are small, ranging between 5 and 15 grams. As the blood sugar still remains normal, and as the daily urine is otherwise free of sugar and acetone bodies, it is difficult to associate this glycosuria with loss of tolerance. My impression is that, some time on these exceptional days, there is a temporary rise of blood sugar, and that, once the blood sugar has reached the renal threshold for glucose, sugar is excreted and excretion may continue for a short time, though the blood sugar may return to the normal or nearly normal. This phenomenon of excretion of sugar in diabetes in the absence of hyperglycæmia, was referred to before by the writer in a study of renal glycosuria, and emphasized as a possible fallacy which has to be considered in the interpretation of blood sugar time curves.[8]

Incidentally, here we have a young diabetic whose diet consists of 254 grams of carbohydrate, and who requires thirty units of insulin a day only, in spite of the presence of an infection.

DISCUSSION

If I have created the impression that all of our results are as those reported in the cases mentioned, I wish immediately to state that they are not. We have had failures. I know of 16 of them and they have been very bad failures. However, in 3 of these the patients did not respond to the older diets. In the 13 remaining cases, failure may be definitely attributed to the dietetic management. May I, however, observe that we have now over 500 patients on this diet and that 16 failures among them is, at least in my opinion, a highly satisfactory state of affairs. Our comparative data also show that, providing patients follow the prescribed treatment, our results are more satisfactory and more uniform than with the older diets. Diabetics, in the final analysis, are only human; they are, therefore, very likely to err and, at times, because of the chronic nature of their disease, they err deliberately. For some time, we had a number of cases of glycosuria which, until the patients were readmitted into the hospital for study, we could not explain. We are, however, now quite convinced that, with very few exceptions, when the high carbohydrate-low calorie diet was not successful, it was not due to some fundamental fault with the diet, but to dietary indiscretion, inadvertent or deliberate, on the part of the patient.

The interesting question which arises is—Why is this diet successful? Experiences with it are incompatible with our present conception of the metabolism of diabetes. An explanation which suggested itself early in our experience was that

*This is our second case of a glycæmia without symptoms. The boy did not complain, nor were there any signs of an insulin reaction. There was practically no glucose in the blood. Thus:

Blood sugar before fermentation = 0.036 per cent
Blood sugar after fermentation = 0.034 per cent

True glucose = 0.002 per cent

(First case reported in *Am. J. Med. Sc.*, 1929, **178**: 29.)

the results were due to its low caloric value. As is generally recognized, providing that these patients are treated on the principle of under-nutrition, it is possible to allow a variety of variations in the carbohydrate, protein and fat. Under-nutrition does not, however, explain the fact frequently noted, that it is possible to change the diet of an individual from 50 grams of carbohydrate, 150 grams fat, and 59 grams protein to 250 grams carbohydrate, 50 grams fat and 75 grams protein not only without the use of additional insulin but with less than required with the former diets; these diets are identical with respect to their caloric value. Past experiences also show that middle-aged diabetics tolerate a variety of diets. This, however, does not explain the good results with this new diet in the case of juvenile and adolescent patients.

In as yet some unknown manner, exposure to this diet appears to lead to an increase in the available supply of insulin. From Allen's classical experiments it was concluded that excess feeding of carbohydrates led to over-strain of pancreatic function in the partially depancreatized dog and loss of carbohydrate tolerance. The question which, therefore, arises is—"Why do not these high carbohydrate diets also lead to loss of carbohydrate tolerance? Not only do they not lead to loss, but, apparently, to improvement. The view held generally at present is that, in diabetes, there is defective production of insulin. Much of our experimental data to date fail to support this view. Diabetes does not appear to be due to defective production of insulin but to interference with the action of a normal supply. Experiences with diabetes complicated by infections are suggestive. The loss of carbohydrate tolerance in these cases is generally attributed to defective insulin production due to the infection. If this view is correct, how are we to explain the not infrequent experience that such patients are not able to make use of the insulin injected hypodermically? As is well known, such persons may fail to respond to huge doses. These are some of the questions which, when settled, may give us a greater insight into the pathogenesis of this disease, and, it is hoped, lead to still further improvement in methods of treatment. Until more is known of diabetes, our treatment must be largely dietetic. From our experiences with the above mentioned routine procedure in determining whether patients do or do not require insulin, our conclusion is that the great majority do not; diet in the majority of cases still remains the most important factor in the treatment of diabetes, and it is my opinion that, providing individuals follow prescribed treatment, the high carbohydrate-low calorie diet can do much in not only keeping the patient alive but in keeping him relatively more comfortable. Parenthetically, may I state that, judging from practice, there are still a number of physicians, unfortunately, who misinterpret such observations and fail to use insulin in cases where its use is indicated. Such practice hardly requires comment.

In a recent appraisal of present day methods of the treatment of diabetes, Dr. Joslin[9] very aptly pointed out that, in view of the satisfactory state of affairs reached, one should be slow to depart from standard methods. Innovation should be confined to hospitals with large clinics and available facilities for thorough study. May I, therefore, again state that were I at all in doubt about the value of this diet, I should hesitate to present it before a group of men who are likely to apply it in general practice.

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A SENSE OF HUMOUR.—Dr. E. Graham Howe in his lectures at Tavistock Clinic, London, discussing the motives and mechanisms of the mind, says: "It is not perhaps generally realized to what extent humour is defensive, its purpose often being to take the edge off a reality which is too unkind. This accounts for humour's close association with tragedy. If we can see the funny side of fear, guilt, and inferiority, we can also see them in some degree of perspective and they have largely lost their unconscious power over us. To laugh when we are afraid helps to restore the balance of courage. . . . A sense of humour will always blunt the edge of inferiority, giving at least the more tolerable quality of the comic and ridiculous. Whether it be shortness of stature, slipping on a banana skin, or feeling sea-sick, it is always good to see it from the funny side. Growth and a sense of humour, then, are the psychological, normal, and desirable means by which we rid ourselves of the undesirable pathological feelings of fear, guilt, and inferiority."